Surgical Treatment of Bullous Emphysema: Experience With the Brompton Technique

Samir S. Shah, MBBS, and Peter Goldstraw, FRCS

Department of Thoracic Surgery, Royal Brompton National Heart and Lung Hospital, London, England

The technique first described by Monaldi has been modified for the treatment of discrete emphysematous bullae. Fifty-eight patients (median age, 56 years) underwent this procedure between 1983 and 1992. The operative mortality was 6.9% (4 patients). Fifty-two patients (89.6%) noted symptomatic improvement, as measured using the modified Medical Research Council of Great Britain dyspnea scale, from a mean value of 3.7 preoperatively to 2.1 postoperatively. Two patients remained unchanged symptomatically. In all patients, amelioration of symptoms was accompanied by an objective improvement in lung function. A mean increase of 28% was noted in the forced expiratory volume in 1 second ($p < 0.05$), and a 12.3% improvement in the total lung capacity was observed ($p < 0.002$). The residual lung volume–total lung capacity ratio declined from a mean of 70% to 57% after operation. A forced expiratory volume in 1 second of less than 500 mL ($p < 0.05$) and carbon dioxide tension of greater than 6.5 kPa ($p < 0.05$) were significant predictors of poor prognosis. The median follow-up period has been 1.9 years (range, 0.5 to 9 years). Two patients have returned for further drainage of new bullae on the operated side, and this was carried out percutaneously in both. We conclude that this technique offers a simple, safe, and effective method for the treatment of discrete bullous disease in patients with emphysema.

Ann Thorac Surg 1994;58:1452–6

Discrete bullae are a well-recognized feature in patients with generalized emphysematous lung disease. They result in space occupation, expanding preferentially at the expense of adjacent lung tissue, which has a more normal compliance. There is an attendant increase in the physiologic dead space and hyperinflation of the lung with loss of elastic recoil. The presence of these bullae may aggravate the dyspnea consequent to generalized lung disease.

Many surgical techniques have been developed to deal with troublesome bullae. Each has the common aims, first, of obtaining symptomatic relief of the dyspnea and, second, of improving lung function. In the main these techniques have concentrated on excising the dominant bullae in the hope that this would result in the reexpansion of adjacent potentially functioning lung tissue.

We describe a series of 58 patients referred to one thoracic surgeon (P.G.) between 1983 and 1992; all underwent operation for bullous emphysematous lung disease using a modification of a technique first described by Monaldi for the drainage of pulmonary cavities after tuberculous infection [1–3].

Material and Methods

The cases of all 58 patients with bullous emphysema who were accepted for treatment were retrospectively reviewed. The decision to operate on a patient was governed by two criteria: first, that the patient suffered from debilitating dyspnea, and, second, that the patient had radiologic evidence of local disease with a pronounced discrete bulla or bullae, in the context of diffuse emphysematous lung disease. Congenital bullae in the presence of otherwise normal lung parenchyma were treated by thoracotomy and resection.

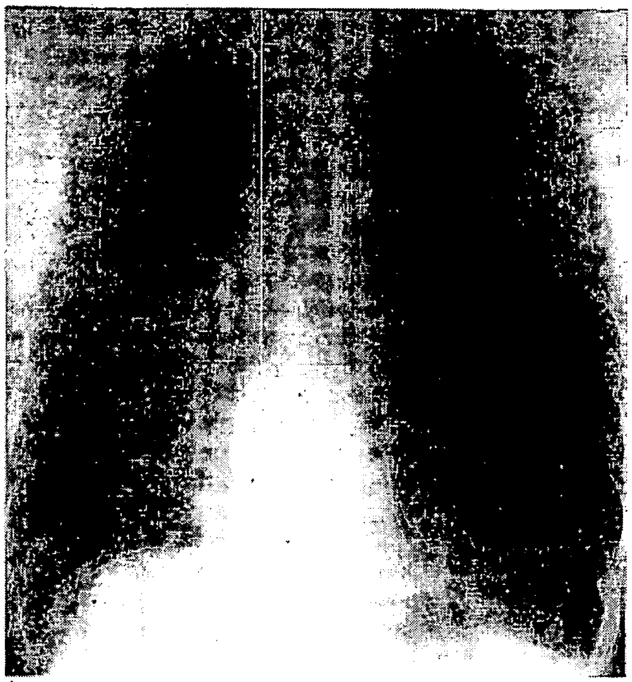
All patients underwent careful history-taking and physical examination. In each patient, an attempt was made to grade the degree of dyspnea using the modified scale devised by the Medical Research Council of Great Britain [4]:

0 = Not troubled with breathlessness except with strenuous exercise
1 = Troubled by shortness of breath when hurrying on the level or walking up a slight hill
2 = Walks slower than people of the same age on the level because of breathlessness or has to stop for breath when walking at own pace on the level
3 = Stops for breath after walking about 100 yards or after a few minutes on the level
4 = Too breathless to leave the house or breathless when dressing or undressing

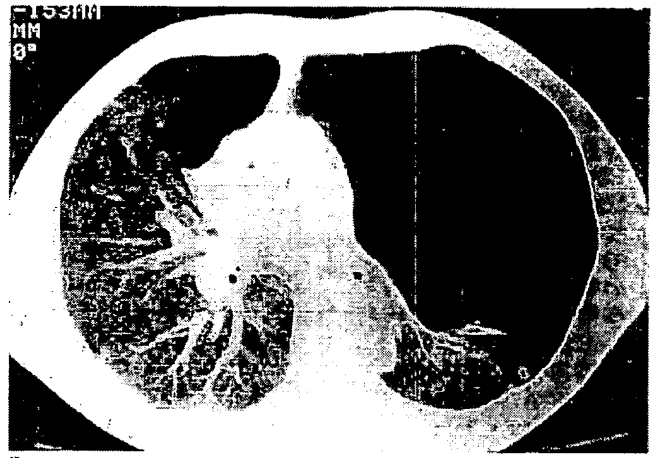
Preoperative assessment consisted of full blood count, simple respiratory function tests including routine spirometry, and measurement of arterial blood gas tensions. In most patients, detailed lung function tests and assessment of lung volumes were also performed. All patients had posteroanterior and lateral chest x-ray studies performed. A computed tomographic scan of the thorax was obtained to identify accurately the position of the dominant bulla, the site of the surgical incision, and the degree of atelectasis of the lung adjacent to the bulla (Figs 1A, 1B). All

Accepted for publication May 4, 1994.

Address reprint requests to Mr Goldstraw, Department of Thoracic Surgery, Royal Brompton National Heart and Lung Hospital, Sydney St, London SW3 6NP, England.



A



B

C

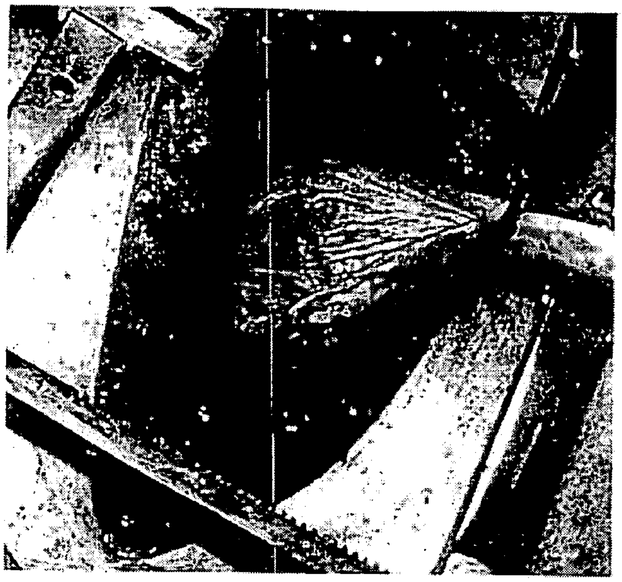
Fig 1. Preoperative chest roentgenogram (A) and thoracic computed tomographic scan (B) of a patient with emphysematous bullous lung disease, showing a large single bulla occupying most of the left hemithorax. (C) The postoperative chest roentgenogram of the same patient. Note the elevation of the left hemidiaphragm and reexpansion of the underlying lung.

patients underwent a period of preoperative inpatient preparation consisting of physiotherapy and bronchodilator treatment to optimize lung function and decrease sputum production.

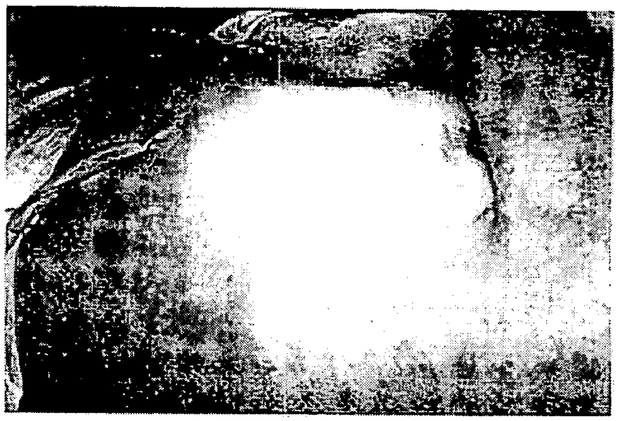
The operation used is a modification of the original technique of Monaldi and consists of a one-stage procedure performed with the patient under general anesthesia. A 5-cm to 7-cm limited thoracotomy is performed, a segment of the underlying rib is resected, and the pleura is opened. The computed tomographic findings determine the site of the incision, and this corresponds to the area where the bulla will come closest to the visceral pleura after decompression. The bulla is opened and two concentric Prolene (Ethicon, Somerville, NJ) pursestring sutures are placed around the opening. The interior of the bulla is then inspected and any septa are perforated to allow free communication between adjacent loculi and bullae. The cavity is then insufflated with iodized talc. A 32F Foley catheter is placed within the bulla, the balloon is inflated with 40 cc of air, and the pursestring sutures are secured (Fig 2A). The Foley catheter acts as a self-retaining intrapulmonary drain that anchors the bulla adjacent to the chest wall. The pleural cavity is then liberally insufflated with talc to obtain an effective postoperative pleurodesis. An intrapleural chest drain is inserted and the wounds are closed in the routine fashion (Fig 2B).

The intrapleural drain is placed on underwater seal suction at 5 kPa, and the Foley catheter is placed on free underwater seal drainage. The former is removed once any air leak ceases, and the latter is removed on the eighth postoperative day regardless of whether any residual air leak exists. This allows a secure bronchocutaneous fistula

Ann Thorac Surg
1994;58:1452–6



A



B

Fig 2. (A) Insertion of a Foley catheter into the dominant bulla after the cavity has been insufflated with talc. (B) Final postoperative appearance of the patient.

to be established, which normally closes within 48 hours after removal of the Foley catheter.

Results

Of the total of 58 patients, 45 were male and 13 were female. The median age was 57 years (range, 40 to 71 years). The mean overall score on the modified Medical Research Council dyspnea scale was 3.7 (range, 2.0 to 4.0) preoperatively.

The mean preoperative values for the forced expiratory volume in 1 second (FEV_1), the ratio of FEV_1 to forced vital capacity, and the arterial carbon dioxide tension were 750 mL (range, 220 to 2,145 mL), 34% (range, 17% to 51%), and 5.2 kPa (range, 4.2 to 8.4 kPa), respectively. Seventeen patients had a preoperative FEV_1 of less than 1,000 mL.

Fifty-two patients noted symptomatic improvement after their operation, with 2 patients reporting no change in their symptoms. The mean overall dyspnea score was 2.1 (range, 1.0 to 3.0) after operation. Amelioration of symptoms was associated with an improvement both in radiologic terms and in the lung function of the patients. The latter was not the case in the patients that remained symptomatically unchanged. A mean increase of 28% was noted in the FEV_1 ($p < 0.05$), and a 12.3% increase in the total lung capacity (as shown by inert gas washout), expressed as a percentage of the predicted value ($p < 0.02$), was also noted. There was a 28% reduction in the residual volume ($p < 0.01$), and, when this was expressed as a percentage of the total lung volume, a mean reduction of from 70% to 57% was noted after operation (Fig 1C).

There were no operative deaths. All patients were successfully extubated at the end of the operation. Intrapleural drains were in place for a mean of 2.9 days (range, 1 to 22 days). The mean length of postoperative hospital stay was 15.1 days (range, 9 to 41 days). Nine patients (15.5%) suffered complications attributed to the procedure and 4 patients (6.9%) died after the operation.

Comment

Bullous disease in the setting of generalized emphysema is a well-recognized problem. For two reasons its presence can be a major contributory factor in compromising the respiratory function of the patient. First, if the bulla is ventilated, this produces an increase in the physiologic dead space. Second, the bulla is hypercompliant and expands preferentially at the expense of adjacent, potentially functioning lung. The latter is in part due to passive atelectasis, as the size and poor elasticity of the bulla lead to failure of the inspiratory expansion of the chest wall to be transmitted to the rest of the lung [5]. In addition, hyperexpansion flattens the diaphragm, resulting in less effective respiratory effort; the patient thus breathes from a high residual volume, and this is inefficient and causes discomfort.

Excision of the bulla not only allows more normal lung tissue to reexpand but also diminishes the physiologic dead space, improves the dynamic compliance of the lung, decreases the airway resistance, and reduces the functional residual capacity of the lung. The diaphragm also rises, making breathing more efficient [6–9]. A variety of surgical methods have been developed for the treatment of this condition. In each case, the aim has been to remove the bulla together with a variable amount of lung tissue, ranging from local excision [10] to either a segmentectomy [11] or the removal of one or more lobes of the lung [12]. In some instances, the bulla is found to be on a narrow pedicle, enabling it to be excised by simple plication of the base, thereby obviating the need for pulmonary resection [13]. All patients undergoing operation for the management of bullous disease have moderate to severe respiratory insufficiency in the setting of generalized and progressive disease, and such patients cannot usually tolerate a further reduction in their respiratory reserve caused by pulmonary resection. In these instances, mortality is high and death in most cases is due to progression of the

underlying lung disease [14, 15]. Inevitable complicating factors include chest infection and the presence of a persistent air leak, the latter due to the poor quality of tissue in an emphysematous lung, making air-tight suturing difficult and delaying healing [16].

The key factors in achieving a favorable outcome are careful selection of the patient for operation, the presence of a single large bulla, and the conservation of as much lung tissue as possible. The size of the bulla is important, as findings from studies have suggested that an improvement in the patient's condition can be expected only when the dominant bulla occupies more than one-third of the hemithorax [10, 12, 13]. The results of surgical treatment are disappointing in patients with multiple small bullae or diffuse emphysema without discrete bullae.

These factors point up the value of adequate preoperative assessment and the importance of defining the nature of the dominant bulla. Many methods have been used to achieve this, including bronchography [17] and pulmonary angiography [18], together with the conventional posteroanterior and lateral chest x-ray studies. We have found that a computed tomographic scan affords a clearer three-dimensional assessment of the dominant bulla, particularly when multiple bullae are present. In addition, a computed tomographic scan allows accurate preoperative planning of the surgical approach in terms of defining the lateral aspect of the dominant bulla where it comes closest to the chest wall, thereby permitting the surgeon to create as small a thoracotomy as possible [19].

Monaldi first described the technique of intracavity suction and drainage as a method of treating posttuberculous cavities. The technique was then adapted to deal with pyogenic abscess cavities [1, 2]. This method was widely adopted by Head and Avery [20] for the treatment of emphysematous bullae. They described a procedure that was performed in two stages to minimize the risk of a pneumothorax. The first stage involved the production of extrapleural adhesions over the bulla using an iodine pack which was kept in place for 3 weeks. In the second stage, the bulla was formally drained. MacArthur and Fountain [21] converted the process to a one-stage procedure in which a Foley catheter was used to drain the bulla. In our modification of these techniques, we instill sclerosant directly into the bulla, thereby producing rapid contraction and fibrosis within the bullous cavity and inducing a talc pleurodesis at the same time [3].

The advantages of this technique are threefold. First, the operation entails a minithoracotomy, which reduces the morbidity and mortality associated with a formal thoracotomy in patients who have poor respiratory function. The morbidity in our series was 15.5% (9 patients), and consisted of wound infection in 3 patients and chest infection with positive sputum culture findings in 4 patients. All patients in the former group responded to simple wound toilet, and those in the latter responded to antibiotics and physiotherapy. Two patients suffered marked generalized surgical emphysema, which resolved with time and did not require active treatment, though the condition did prolong the postoperative hospital stay in both patients (35 and 41 days).

The mortality in our patients was 6.9% (4 patients), and this compares favorably with the mortality noted for other studies, ranging between 2% and 26% [10, 11, 15, 17, 20–22]. One patient suffered staphylococcal septicemia. Three patients died as the result of respiratory failure secondary to their underlying lung disease. In each, the preoperative FEV_1 was less than 500 mL—220 mL (this patient also had α_1-antitrypsin deficiency), 350 mL, and 480 mL.

Overall we found that a preoperative FEV_1 of less than 500 mL ($p < 0.05$) and an arterial carbon dioxide tension of greater than 6.5 kPa ($p < 0.05$) were both significant predictors of a poor outcome after operation. We now consider a preoperative FEV_1 of 500 mL and an arterial carbon dioxide tension of less than 6.5 kPa as the minimum prerequisites for operation.

The second advantage of our technique is that it does not involve the loss of lung tissue. The best results in terms of symptomatic improvement and mortality have been achieved in cases in which the bullae were either excised or decompressed without the resection of any lung tissue [2, 3, 20]. It has been suggested that, if pulmonary resection is necessary, it should encompass an entire lobe of the lung rather than be a wedge resection. However, lobectomy has been criticized as it necessitates the removal of both functioning and nonfunctioning lung tissue [22].

The third advantage is that pleurodesis achieved at operation allows the intubation and drainage of any subsequent bullae percutaneously with the patient under local anesthesia, with minimal risk of a pneumothorax. This has been performed successfully in 2 patients in whom new bullae developed on the operated side.

With the increasing interest in endoscopic surgical procedures, the role of thoracoscopy in the treatment of bullae, both in patients with spontaneous pneumothorax and more recently in those with emphysematous lung disease, has been investigated in several series. The techniques have utilized a conventional stapler, electrocautery, and lasers [23–25]. The attractiveness of a procedure that purports to achieve the same result as a thoracotomy, but that is less invasive, is self-evident. The key disadvantage of thoracoscopic ablation is that patients need to be maintained on one-lung ventilation for a considerable period during the operation. Barker and associates [26] reported a mean duration of one-lung ventilation of 170 ± 53 minutes (with 6 patients requiring almost 240 minutes). In addition, they noted a significant incidence of hypoxemia and the fact that all patients required a period of mechanical ventilation postoperatively. The anesthetic problems associated with the surgical treatment of bullous emphysematous lung disease are well recognized, and long periods of one-lung ventilation inevitably render the peroperative and postoperative anesthetic management of these patients more complex [26, 27]. Wakbayashi and associates [24] also noted that all patients displayed signs of acute lung injury after the laser ablation, though it is not clear whether this represents reperfusion injury, reexpansion interstitial pulmonary edema, or laser thermal injury. The conversion rate from thoracoscopic ablation to thoracotomy was relatively high in both series—18% and 13.7% for Barker's and

Wakbayashi's series, respectively, with the latter author reporting a mortality rate of 10% [24, 26].

Despite its clear potential, the thoracoscopic treatment of bullae in emphysematous lung disease does have some fundamental problems that need to be addressed. In the meantime, we believe that the one-stage technique consisting of intracavity suction and drainage plus talc pleurodesis offers a simple, safe, and effective way to manage this condition. More importantly, the symptomatic benefit seen postoperatively is supported by an objective improvement in respiratory function.

References

1. Monaldi V. Tentativi di aspirazione endocavitaria nelle caverne tuberculari del pulmone. Lotta Contro la Tuberculosi 1938;9:910–1.
2. Monaldi V. Endocavitary aspiration: its practical application. Tubercle 1946;28:223–8.
3. Venn GE, Williams PR, Goldstraw P. Intracavity drainage for bullous, emphysematous lung disease: experience with the Brompton technique. Thorax 1988;43:998–1002.
4. Mahler DA, Wells CK. Evaluation of clinical methods for rating dyspnea. Chest 1988;93:580–6.
5. Boushy SF, Kohen R, Billig DM, Heiman MJ. Bullous emphysema: clinical, roentgenologic and physiologic study of 49 patients. Dis Chest 1968;54:327–34.
6. Pride NB, Barter CE, Hugh-Jones P. The ventilation of bullae and the effect of their removal on thoracic gas volumes and tests of overall pulmonary function. Am Rev Respir Dis 1973;107:83–98.
7. Ray JF III, Lawton BR, Smullen WA, Myers WO, Saulter RD. Effective surgical palliation of giant compressive bullous emphysema (vanishing lung syndrome): long-term follow-up. Am Surg 1976;42:181–5.
8. Rogers RM, DuBois AB, Blakemore WS. Effect of removal of bullae on airway conductance and conductance volume ratios. J Clin Invest 1968;47:2569–79.
9. Mead J, Lindgren I, Gaensler EA. Mechanical properties of the lungs in emphysema. J Clin Invest 1955;34:1005.
10. Wesley JR, Macleod WM, Mullard KS. Evaluation and surgery of bullous emphysema. J Thorac Cardiovasc Surg 1972;63:945–55.
11. Head JM, Head LR, Hudson TR, Head JR. The surgical treatment of emphysematous blebs and localized vesicular and bullous emphysema: analysis of 50 cases. J Thorac Cardiovasc Surg 1960;40:443–60.
12. Woo-Ming M, Capel LH, Belcher JR. The results of surgical treatment of large air cysts of the lung. Br J Dis Chest 1963;57:79–85.
13. Fitzgerald MX, Keelan PJ, Cugell DW, Gaensler EA. Long-term results of surgery for bullous emphysema. J Thorac Cardiovasc Surg 1974;68:566–87.
14. Brantigan OC, Mueller E, Kress MB. A surgical approach to emphysema. Am Rev Respir Dis 1959;80:194–206.
15. Hugh-Jones P, Ritchie BC, Dollery CT. Surgical treatment of emphysema. Br Med J 1966;1:1133–8.
16. Parmar JM, Hubbard WG, Matthews HR. Teflon strip pneumostasis for excision of giant emphysematous bullae. Thorax 1987;42:144–8.
17. Potgieter PD, Benatar SR, Hewitson RP, Ferguson AD. Surgical treatment of bullous lung disease. Thorax 1981;36:885–90.
18. Jensen KM, Miscall L, Steinberg I. Angiocardiography in bullous emphysema: its role in selection of the suitable case for surgery. AJR 1961;85:229–46.
19. Morgan MD, Denisson DM, Strickland B. Value of computed tomography for selecting patients with bullous lung disease for surgery. Thorax 1986;41:855–62.
20. Head JR, Avery EA. Intracavitary suction (Monaldi) in the treatment of emphysematous bullae and blebs. J Thorac Cardiovasc Surg 1948;18:761–76.
21. MacArthur AM, Fountain SW. Intracavity suction and drainage in the treatment of emphysematous bullae. Thorax 1977; 32:668–72.
22. Knudson RJ, Gaensler EA. Collective review: surgery for emphysema. Ann Thorac Surg 1965;1:332–62.
23. Torre M, Belloni P. Nd:YAG laser pleurodesis through thoracoscopy: new curative therapy in spontaneous pneumothorax. Ann Thorac Surg 1989;47:887–9.
24. Wakabayashi A, Brenner M, Kayaleh RA, et al. Thoracoscopic carbon dioxide laser treatment of bullous emphysema. Lancet 1991;337:881–3.
25. Lewis RJ, Caccavale RJ, Sisler GE. VATS-argon beam coagulator treatment of diffuse end-stage bilateral bullous disease of the lung. Ann Thorac Surg 1993;55:1394–9.
26. Barker SJ, Clarke C, Trivedi N, Hyatt J, Fynes M, Roessler P. Anesthesia for thoracoscopic ablation of bullous emphysema. Anesthesiology 1993;78:44–50.
27. Gothard JWW, Branthwaite MA. Anaesthesia for thoracic surgery. London: Blackwell, 1982:134–43.